Traffic data analysis in Sitraffic Scala/Concert

The expert system for visualization, quality management and statistics
Traffic data analysis produces “transparent intersections”

The traffic control equipment at intersections is more diverse than ever. Traffic signals control the traffic, prioritization systems for buses and trams give priority to public transport, detector systems measure the volume of traffic, enforcement cameras monitor the drivers’ behavior at red lights and their compliance with speed limits etc. An immense amount of data is involved. Right around the clock, at each and every intersection!

From this mass of data, the traffic data analysis algorithms in Sitraffic Scala/Concert generate useful information and deliver automatic quality management. The result: “transparent intersections” thanks to easy and automatic online monitoring. The wide range of available analyses also provides a reliable statistical basis for planning future traffic infrastructure.

Three components, one system
The traffic data analysis in Sitraffic Scala/Concert consists of three components: Visualization of Traffic Signal Data, Traffic Signal Quality Management, and Sitraffic Statistics. In combination, these three form an integrated system solution for automated quality assurance of intersection control and monitoring, as recommended by the German Traffic Signal Control Guidelines (RiLSA) 2010. As part of the Sitraffic family of systems, the three components are incorporated into the Sitraffic traffic platform and can be operated as function modules within Sitraffic Scala and Sitraffic Concert.

Sitraffic Scala Visu:
Visualization of traffic signal data
This module visualizes the current and past switching operations and states of the signal timing plans online in the site plan and displays green waves. Thus, for example, the exact signaling states can be displayed in detail to enable analysis of the program, including additional information from detectors, public transport messages and traffic actuation. The data can be accessed online.

Sitraffic QM:
Quality management for traffic signals
This module monitors situations such as waiting times upon green request for both pedestrians and vehicles as well as travel times for public transport. With quality control, quality summaries and quality analysis as its three pillars, the traffic data analysis in Sitraffic Scala/Concert constitutes an ideal and easy-to-use tool for the diagnosis and analysis of quality deficits.

Sitraffic Statistics:
Analysis of traffic data
This module provides quality assessments and other freely definable evaluations of data from all types of sensors that are connected (8+1 detectors, ANPR, environmental detectors, TEU). Pre-defined reports include schedules of peak hours, fundamental diagrams and traffic load profiles – from minute-by-minute charts right through to annual profiles of daily traffic volumes. When it comes to developing meaningful strategies for future transport infrastructure measures, this is an indispensable tool.
Sitraffic Scala Visu:
Visualization of signal timing plans, intersections and green waves

These days, professional visualization in the form of meaningful graphical representations is vital for monitoring and improving the complex workings of a modern traffic control system. With the traffic analysis system in Sitraffic Scala/Concert, we offer a fully integrated, online-enabled visualization solution that provides the best possible support to traffic engineers. The solution includes function modules for the visualization of signal timing plans, intersections and green waves.

**Visualization of signal timing plans for analyzing signal program processes**
Using this function, the switching history of the signal plan can be displayed. The current signal plan and key signal states are archived for each traffic signal, and can be subsequently reproduced as graphical representations. Switching parameters or disruptions can be easily monitored over long periods. The parameter list shows the most important central parameters in a structured manner. For each circuit, the signal plan, equipment status, operating mode, control level and local traffic actuation parameters are listed. A user-friendly search method makes the visualization of historical switching states easy.

This module also graphically displays signaling states, detector data, public transport messages and AP values of traffic actuation, even for several intersections within a single visualization. The user can display current as well as archived values covering a defined time period. The visualization of the second-by-second states is useful in the analysis of signal program processes. In order to support the intuitive understanding of the process, the real signaling states at an intersection are shown in the appropriate colors (red, amber, green) and in the form of a signal timing plan.

**Visualization of intersections for a realistic overview**
The main purpose of this module is the second-by-second visualization of the states of signal groups, detectors and AP values as realistically as possible, reflecting the layout of the intersection in question. Symbols represent the signaling states such as red, amber, green, red and amber, dark and flashing. The signal group switching can be viewed online.

**Visualization of a green wave in a time-distance diagram**
This representation is important in order to be able to analyze the coordination of private and public transport on the basis of the actual distances along the route. The module uses a time-distance diagram to visualize how the intersections are actually coordinated with each other and whether vehicles can pass through a certain number of intersections without stopping. The calculations are based on a defined average speed. The second-by-second public transport messages from the signal groups and the signaling states in one section of the route are used as a database.
Visualization of intersections
The system provides visualization of individual intersections, including defined traffic flows. The signal group switching states are displayed online.

Visualization of green waves
Along the x-axis, the intersections with their stop lines for both traffic flow directions are represented in proportion to the real distances. On the y-axis, the signaling states, green bands and public transport trips, including the applicable time stamps, are shown.

Online visualization of signal plan
The signal timing plan visualization is an accurate representation of the second-by-second states of the defined signal groups, detectors and AP values along the x-axis.
Quality management in three stages: from quality control to quality summary and finally to quality analysis

**Quality control**
- Online traffic checks based on threshold values
- Checks on motorized private transport, public transport and pedestrians
- Automatic threshold generator based on planning parameters
- Generation of operating status messages possible

**Quality summary**
- The report sheet provides a daily summary of the quality of the traffic signals
- The management overview (hot-spot representation) uses quality values to pinpoint quality deficiencies
- The quality values are calculated on the basis of the deviations from threshold values revealed in the quality control stage

**Quality analysis**
- Analysis of motorized private transport, public transport and pedestrians
- Graphical analysis, with the facility to zoom to each quality control instance
- Quality analysis can be called up either as a stand-alone function or via Sitraffic Office

The quality management module provides an automatic threshold generator for the quality control system, with a range of choices. When copying an intersection version, the threshold values can be transferred.

Thresholds for the quality control system are generated automatically and are easy to edit manually.
Sittraffic QM: Quality management for traffic signals

Identification, structured visualization and a meaningful analysis of any quality deficiencies in traffic control at intersections used to be a tedious affair. Not anymore: The traffic signal quality management module provides a very simple solution. The system determines the quality of private transport, public transport and pedestrian traffic at the intersection and works through the data in three stages:

1. The **quality control module** automatically identifies quality deficiencies by continuously and automatically searching for faults and failures (threshold value comparisons); wherever these occur in larger numbers, alerts are issued in the form of operating status messages.

2. The **quality summaries** list the quality deficiencies in a structured manner. They provide an overview of the quality of the traffic signal equipment, pointing out critical issues and organizing the data according to different quality aspects.

3. The **quality analyses** evaluate the known deficiencies in a range of different ways and in line with a variety of specific queries: faults and failures listed in the quality summaries, road users’ complaints, and problems identified by traffic engineers.

The system monitors all the states and reviews the number of messages generated by public transport as well as public transport travel times. As the quality management module is an integrated system solution, the generation of threshold values is automatically carried out by the system. And because quality analyses are assigned to each quality control, deficiencies can be easily analyzed and resolved quickly.

1. Quality control module: Automatic troubleshooting around the clock
   The quality control system monitors measured traffic data through comparison with parameterizable thresholds. In the case of traffic signals with complete basic configuration data (OCIT in-stations data), these threshold values can be generated automatically and edited manually – a simple, quick operation. To limit the number of reports to only the really necessary ones, a distinction is made between the threshold values that only flow into the summaries and analyses and those that trigger an operating status message. The quality control results are available for the compilation of quality summaries (hot-spot display and report sheet).

**Quality controls**

**Private transport:**
- Comparison of state durations against pre-defined thresholds, particularly important in traffic-actuated control systems
- Monitoring of green times on the basis of the master plan; this allows green wave monitoring
- Monitoring of request waiting times (time between the detection of a request by the detector and start of the green time of the associated signal group)
- Check of detector counter values in relation to an interval
- Review of the green times of a signal group for fluctuations (variance); this checks whether a traffic-actuated control is active

**Public transport (PT):**
- Check of the minimum and maximum number of messages (PT reporting points)
- Comparison of deviations of log-in and log-out numbers (number of messages)
- Control of public transport journey times within an intersection by comparison of scheduled and actual times

**Pedestrians:**
- Monitoring of waiting times between the moment the green-request button is pressed and the start of the green time of the associated signal group
2. Quality summaries: 
A daily updated overview of traffic signal quality at your fingertips
The quality management system ensures that the current quality level of the traffic signals can be viewed at any time. The system automatically creates a daily report sheet, on which equipment in critical state is immediately noticeable. The pages of the report are archived in a clearly arranged tree structure. Comparison of the day’s data with reference values from the previous day makes any quality trends visible at first glance. The hot-spot display provides a comprehensive overview of the key parameters for both individual and public transport.

3. Quality analyses: 
The management overview is just a mouse click away
The wide range of options for the analysis of motorized traffic, pedestrian traffic and public transport (at an intersection and on a route) form the core of the traffic signal quality management system. All analyses can be called up directly from the Sitraffic Scala traffic computer or the stand-alone system. Operation is very simple – just one click with the mouse on the relevant line on the main screen, the hot-spot display. If threshold values are available, they are visualized in the different analyses. If no thresholds are defined, they can be created for the visualization.

Quality analyses of intersections and routes

Private vehicle analyses at intersections:
- Start of green time
- State duration of the signal groups
- Detector values
- Degree of saturation
- Request times

Public transport analyses at intersections:
- Travel times for public transport at the intersection
- Public transport trip profile at the intersection
- Frequency distribution of public transport messages
- Timetable situation at intersections
- Reporting times – frequency, batched up
- Reporting times – signal times
- Functional check of reporting points

Analyses of public transport routes:
- Trip profile
- Public transport travel time on route
- Timetable situation for route
- Timetable situation – frequency

Pedestrians:
- State durations of signal groups
- Request times
Private transport analysis at intersections

Time series of state durations
The state durations are analyzed to find unacceptable conditions, e.g., 120 seconds of red time. The following signal group states are monitored: green, red, dark, free and blocked.

Time series of start of green times
The switching times of successive signal groups are recorded to assess the quality of a coordinated signal control system (i.e., the "green wave" is checked).

Time series of green time variance
If the green times change from one sequence to the next (variance), this is a sign of an active traffic-actuated control system.

Time series of the private transport saturation level
The variation over time of the saturation level of each detector in a signal group is shown.
Time series of the waiting times upon green request for pedestrians or private transport
The time elapsed between the detector request and the start of the green time is monitored. This identifies any extended waiting times for pedestrians and motorized individual traffic. Threshold value bandwidths (green) and threshold value overruns (red) can be seen at a glance.

Time series of analysis values for pedestrians and private transport detectors – profiles
To identify faulty detector measurements, the detector counter values are checked. The detector values are either visualized as a time-variation curve or in tabular form.

Analysis of public transport at intersections

Histogram of public transport travel times at intersections
Public transport travel times are analyzed to obtain information concerning the efficiency of public transport prioritization measures. To this end, the system provides different ways of looking at the subject, such as travel times changing over time and their frequency distribution.

Time series of public transport green times at the intersection
In this diagram, the login and logout time for each recognized single journey is plotted against the green time of that signal group. This allows the influence of public transport on traffic signal switching to be analyzed.
PT trip profile via reporting points at the intersection
Based on the reporting periods, the travel time from login to logout is represented graphically. The diagram shows the trip profile of individual PT lines at that intersection.

Number of PT messages at the intersection
The data transmission quality of the reporting system is monitored by checking the number of messages. Fluctuations in the number of messages suggest transmission problems.

Number of PT messages per PT line at the intersection
The number of messages is shown separately for each line, route and direction. For different time intervals, the number of messages will be batched together according to reporting point.

Export function for further analysis
The table display allows the immediate matching of a specific event and its precise time of occurrence and provides a facility for quick import into Excel for further processing.
Analysis of public transport along the route

PT trip profile and timetable situation along the route
The trip profile and timetable situation give an overview of the overall quality of a specific PT route. The time is plotted on the x-axis and the travel time on the y-axis.

Timetable situation: deviations from the timetable along the route
This graph shows the frequency distribution of deviations from the timetable at the individual intersections on the route. Any threshold overruns are immediately identifiable.

Frequency distribution of the PT trip profile along the route
The graph shows the frequency distribution of travel times for the selected route.
The hot-spot display: a single screen for key data relating to private and public transport

The hot-spot display is the starting point for quality analysis. The intersection with the worst quality is always the one displayed first. All traffic signals with a rating below 60% are shown in red and stand out immediately. The individual quality analyses can be opened by clicking on the corresponding line.

Please open the quality analyses in this brochure by unfolding these two pages!

Quality summary, updated daily: the report sheet

This report sheet is a purely static representation of a day's quality control results. The worst results are presented in concise graphical form in a table labeled with control center number, intersection name, intersection number and the associated quality ratings, plus any trends compared to the previous day.
Quality evaluations of all devices – e.g. long-term evaluation
Every hour, the quality value is calculated for a device, reflecting the state of the system over time.

Short-term evaluations – e.g. comparing daily profiles
Traffic volumes, occupancy and travel speeds can be represented in profiles with different levels of aggregation.

Long-term evaluations – e.g. average daily traffic volumes
An important parameter for traffic statistics is the average traffic volume for different groups of days. They are shown over a selected time period, including peak hour(s).

Long-term evaluations – e.g. average daily profile
Average profiles can be displayed for periods of up to one year. It is possible to pre-define the type of day, such as holidays or vacation days, by using the time selector.

Fundamental diagrams – e.g. speed against traffic volume
Fundamental diagrams graphically represent the (inter-)dependence of traffic-related parameters such as traffic volume, speed and occupancy. From these, the limits for the level of service can be easily derived.
Sittraffic Statistics: Analysis of traffic data

Statistical surveys and evaluations are essential for the precise planning and development of the transport infrastructure. Sittraffic Statistics provides an integrated system solution with which such surveys and evaluations can be produced easily, quickly and in a demand-oriented manner. The most important uses are, in the main, the analysis of the development and distribution of traffic and the provision of traffic data to other authorities. Sittraffic Statistics is also available as a stand-alone system and can be installed on any PC.

Access to all measured values in the system

With Sittraffic Statistics, the traffic engineer can generate reports for all measured values in the entire system. The measured values are processed and displayed graphically or in tabular form. The evaluations include listings of peak hours, fundamental diagrams, minute-by-minute profile sequences right up to the evaluation of daily traffic volumes across an entire year.

The integrated system solution not only enables the analysis of data collected at intersections, but also the statistical processing of data from other systems such as parking guidance systems (e.g. parking lot occupancy) and traffic management systems (e.g. travel times).

Easy operation and use

Many expert evaluations of traffic data are already pre-defined (e.g. DTV & fundamental diagrams) and therefore easy to adapt to the required parameters. Default settings can be saved at any time and used for the analysis of other devices or time periods. The data can be aggregated for short-term data, freely customizable reports and quality assessments. This means that detailed data sets are combined into larger units, so that they can be easily understood and interpreted. An example of this is the conversion of minute values to hourly values.

The following aggregations are offered by the system:
- in minutes:
  - 1, 5, 10, 15, 30 minutes
- in hours:
  - 1, 4, 6, 12 and 24 hours

Scheduled report generation

With Sittraffic Statistics, reports can be generated according to schedule, e.g. at night. This facility is especially useful for reports that require a lot of time to produce because of the high data volume involved, e.g. monthly and annual reports. Evaluations only need to be defined once, and then are carried out automatically, on a weekly, monthly or quarterly basis.

Overview of reports

Quality of individual devices
- Traffic signal systems, detectors, subsystems, cameras, dynamic panels & car parks

Pre-defined reports
- Short-term data
- Long-term data
- Fundamental diagrams

Freely definable reports
- Evaluation of the levels of measured value processing
- Line and bar charts, tables
  - Traffic signal data
  - Subsystems
  - Environmental detectors
  - ANPR travel times
  - Dynamic panels
  - Car park occupancy
The information in this document contains general descriptions of the technical options available, which do not always have to be present in individual cases. The required features should therefore be specified in each individual case at the time of closing the contract.